Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava
číslo 1, rok 2008, ročník LI, řada hutnická
článek č. 1367

ANALYSIS OF PSG PARAMETERS' SETS USED TO DIAGNOSE ALCOHOL ADDICTION

R. ŚLUBOWSKI, K. LEWENSTEIN, E. ŚLUBOWSKA

Warsaw University of Technology; Warsaw, Poland, lewenk@mchtr.pw.edu.pl

ABSTRACT: The results of detection of alcohol addiction based on the analysis of human sleep are presented in this paper. Sleep was described by numerical parameters calculated from the standard processed records of polysomnography (PSG) signals.
The database used in the experiments consisted of almost 200 examinations: 50% of healthy and alcoholic addicted patients, and 50% males and females, with normal age distribution.
We have used neural networks to evaluate the diagnostic value of the set of sleep parameters. We have proposed 9 sets of basic parameters to detect alcohol addiction. The differences in diagnostic value of these sets are noticeable (from 70% to 77%). Better results were taken by optimisation of number of PSG parameters inside set. Minimal number of parameters that leads to proper learning process is 6 (6 stages of sleep). We have noticed the exchange of the number of input parameters and number of neurons in hidden layer of NN.
Finally, we have obtained above 75% correctness of alcohol addition diagnoses.

KEY WORDS: neural network, alcohol addiction, polysomnography

I. INTRODUCTION

Polysomnography (PSG) is an overnight test used to evaluate abnormalities of sleep and/or wakefulness and other physiologic disorders that have an impact on or are related to sleep and/or wakefulness. A polysomnogram consists of a simultaneous recording of multiple physiologic parameters related to sleep and wakefulness. By international standards, a polysomnogram have to include at least 4 neurophysiologic channels: one electroencephalo-graphy (EEG), two electrooculogram (EOG) channels and one electromyography (EMG) channel. The overnight recording is divided into epochs of approximately 30 seconds. According to standard procedure [4] predominant stage of sleep is assigned to the entire epoch on the basis of EEG, EMG, and EOG recordings. The total time of sleep and time spent in each of the 6 sleep stages are calculated. The examples of the processed polysomnography record of a sleeping patient (so called hypnograms) are presented in Fig. 1. Sleep duration is shown on the horizontal axis and six stages of sleep on the vertical one. The four records presented are examples of a healthy male, female, and an alcoholic male and female.
Changes of some sleep parameters (sleep latency, total sleep time, stage REM, stages: 3, 4, REM latency) had been observed in most of researches, concerning an influence of alcohol addiction on sleep pattern. The findings were collected and briefly characterized in Kirk J. Brower's study [1]. In the paper [3] we have used neural networks for the preliminary research on detection of alcohol addiction on the basis of sleep parameters. Here we want to show diagnostic value of particular sets of features calculated from PSG recordings.

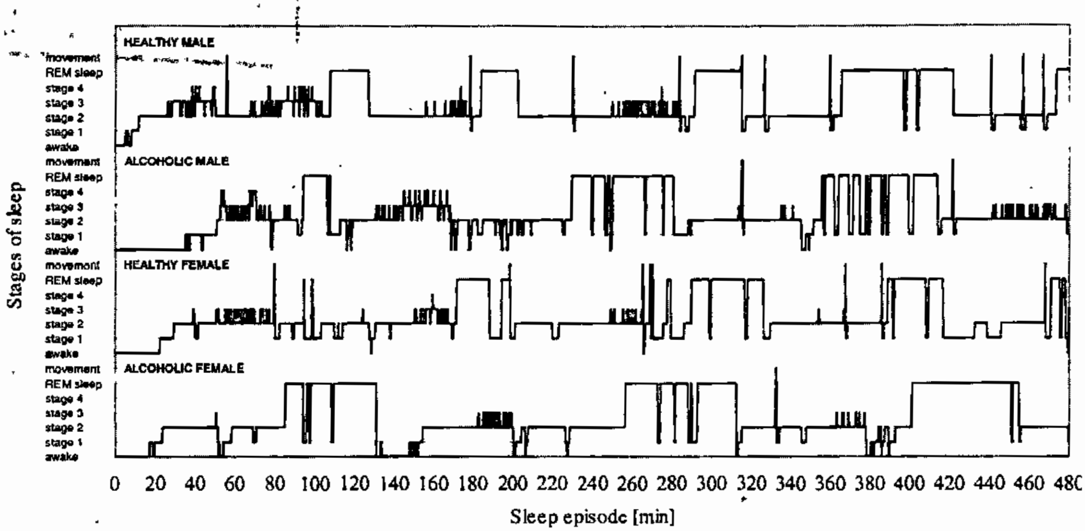

Fig. 1: Typical hypnograms obtained from healthy and alcoholic subjects.

2. MATERIALS

We have used the database consisting of almost 200 examinations containing processed records of the polysomnography signals of alcoholics and age-matched healthy control subjects. There were 85 healthy and 87 alcoholic patients, 86 males and 86 females. Detailed description of the collected data was presented in the paper [3].

Twenty-six numerical parameters characterizing sleep saved in the database are presented in Table 1. There are some general indicators (concerning the whole sleep) and those more detailed (referring to the isolated characteristic stages of sleep [4]). The recognition of alcohol addiction (i.e. medical statement if the patient is addicted) is an essential supplement to the collected data.

3. METHODS

We have used neural networks as a standard software tool in a multidimensional data analysis. In our experiments, networks were trained according to the strategy "with the teacher". The role of the teacher was played by the medical diagnosis of the subject's condition.

We have modeled a perceptron type neural network, with one hidden layer. The number of neurons in this layer was assessed experimentally as the lowest possible number enabling network training (to the almost zero training error). The input layer contained as many neurons as features describing the patient's sleep. The output (decision) layer contained only one neuron responsible for detecting alcohol addiction. According to the literature, as well as the author's experience [2], a network of such architecture has the greatest ability to generalize.

The Stuttgart Neural Network Simulator (SNNS - free-available software simulator) has been used in our studies to build and train networks used in the experiments.

We have implemented the "Quickprop" training algorithm with continuous sigmoid activation of neurons, because of the character of data.

A classic four divided cross–validation method, multiple random initialisations and network trainings [3] have been used in order to check the correctness and repeatability of the results. The test's results of ten networks were averaged to get partial results. These partial results, after ultimate averaging for four divisions, provided us with the percentage of correct detected persons (Fig. 2) what could be understand as the diagnostic value of the particular set of data.

Tab. 1: Specification of sleep parameters and sets of parameters used in the experiments.

Parameter / Set of parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	min	min	min	min	%	%	min	%	min	%	min	%	min	%	min	%	min	%	min	%	min	min	min			min
	Total recording time	Total sleep period	Time of awaking	Total sleep time	Sleep maintenance	Sleep efficiency	Stage 1 NREM	Stage 1 NREM	Stage 2 NREM	Stage 2 NREM	Stage 3 NREM	Stage 3 NREM	Stage 4 NREM	Stage 4 NREM	Stage 3 plus 4 NREM	Stage 3 plus 4 NREM	Stage NonREM	Stage NonREM	Stage REM	Stage REM	Sleep latency	REM latency	Latency to stage 3 and 4	The number of awakes	The number of REM episodes	Average time of cycle
Set I	X	X	X	X	X	X	X		X		X		X		X		X		X		X	X	X	X	X	X
Set II			X	X			X		X		X		X						X		X	X	X	X	X	X
Set IIA			X	X			X		X		X		X						X		X	X		X	X	X
Set IIB			X	X			X		X		X		X						X		X	X		X		X
Set IIC			X	X			X		X		X		X						X			X		X		X
Set III			X	X			X		X		X		X						X			X		X		
Set IIIA			X	X			X		X		X		X						X					X		
Set IIIB			X	X			X		X		X		X						X							
Set IV			X				X		X		X		X						X							

We have built some sets of data describing patients. Set I (Table 1) includes only 19 parameters because some of 26 mentioned features were expressed both in minutes and in percents of total sleep time. There are also parameters, which can be calculated on the basis of the others from that set, for example "stage3 plus stage4". Therefore, we can simplify the analyzed set to only 13 parameters (Table 1, Set II).
Then we removed parameters one by one (Table 1, Sets IIA, IIB, IIC, III and IIIA) to get the best result of diagnosis. Next, parameters were removed until network stops training (Table 1, Sets IIIB and IV). For each set we have optimized number of hidden neurons.

4. RESULTS AND DISCUSSION

The averaged results of neural network analyses are presented in Fig. 2. Network structure (number of neurons in input, hidden and output layers) is shown in brackets under the bars.

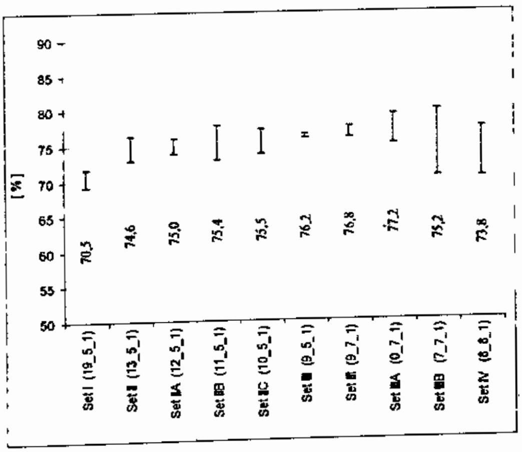

Fig. 2: Average results of alcohol addiction's detection made by particular networks.

On the basis of the proposed sets (Table 1) we obtained results from 70.5% to 77.2% correctness of diagnoses (Fig.1). We can see that base set (Set I - 19 parameters) gives the worst results. It means that some parameters are unnecessary and we should optimise set of input parameters. Leaving only nine parameters from Set III increases correctness of the diagnose to 76.2% with the same number of hidden units of the NN.
Further reduction of parameters (Sets IIIA, IIIB and IV) caused that network was unable to learn (training error didn't decrease to near zero values) and we had to expand network structure. Therefore we added hidden neurons, so network was able to learn, but obtained results weren't better (75.2% and 73.8%).
Set IV consists of 6 basic PSG parameters – 6 stages of sleep. It is minimal set of parameters enabling learning process. W tried to teach network with only 5 parameters, but even increasing number of hidden neurons didn't lead learning process to the successful end.

5. CONCLUSIONS

The research described in the paper leads to the following conclusions:

- Use of the NN and compressed features vector gives us a correctness of the diagnosis above 75%;
- The diagnostic values of sets calculated from the PSG are noticeable (the difference of the diagnosis correctness lies between 70.5% and 77.2%).
- The best results has been obtained with the optimize set (Set III) consists of nine the most important features.
- We can reduce the number of input parameters (Set III), but we should add some hidden units of NN to calculate the necessary values by the network.
- When number of basic parameters is less than 6, network is unable to learn, regardless of number of neurons in hidden layer.

We think that the maximum of the diagnosis correctness could be about 80% using described PSG record and the optimal features vector for men and women, improved by the patient's detailed data. It could mean for example the history of alcohol addiction and the therapy.
The length of particular sleep stages changes during the time of sleep. The parameters used in the experiments have been calculated as total sums of the six stages obtained from successive sleep cycles. We consider that all the stages are essential for the diagnosis. The internal information is not complete and it is necessary to take into account these changes to increase the reliability of diagnoses. Therefore, we propose to divide the total time of sleep on some periods, hoping that it will give us the better results.

6. REFERENCES

[1] BROWER K. J.: *Alcohol's Effects on Sleep in Alcoholics*. Alcohol Research & Health, Spring, 2001 (3/22/01).

[2] LEWENSTEIN K.: Artificial neural networks in the diagnosis of coronary artery disease based on ECG exercise tests. Warsaw 2002, Oficyna Wyd. P.W., Electronics vol. 140.

[3] LEWENSTEIN K., ŚLUBOWSKA E., JERNAJCZYK W., CZERWOSZ L.: *Detection of alcohol addiction based on PSG sleep patterns*. Polish Journal of Medical Physics and Engineering 2006 Vol.12 No.3; 121-130.

[4] RECHTSCHAFFEN A., KALES A.: A manual of standardized terminology techniques and scorning system for sleep stages of human subjects. BIS/BRI. UCLA, (1968): Los Angeles.